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Research

Impact of COVID-19-related health care disruptions on pathologic cancer staging during the first pandemic year: a retrospective cohort study from March 2018 to March 2021

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Abstract

Background: The COVID-19 pandemic has created major disruptions in cancer care, with reductions in diagnostic tests and treatments. We evaluated the impact of these health care–related changes on cancer staging by comparing cancers staged before and during the pandemic.

Methods: We performed a retrospective cohort study at London Health Sciences Centre and St. Joseph's Health Care London, London, Ontario, Canada. We evaluated all pathologically staged breast, colorectal, prostate, endometrial and lung cancers (the 5 most common cancers by site, excluding nonmelanoma skin cancer) over a 3-year period (Mar. 15, 2018–Mar. 14, 2021). The pre-COVID-19 group included procedures performed between Mar. 15, 2018, and Mar. 14, 2020, and the COVID-19 group included procedures performed between Mar. 15, 2020, and Mar. 14, 2021. The primary outcome was cancer stage group, based on the pathologic tumour, lymph node, metastasis system. We performed univariate analyses to compare demographic characteristics, pathologic features and cancer stage between the 2 groups. We performed multivariable ordinal regression analyses using the proportional odds model to evaluate the association between stage and timing of staging (before v. during the pandemic).

Results: There were 4055 cases across the 5 cancer sites. The average number of breast cancer staging procedures per 30 days increased during the pandemic compared to the yearly average in the pre-COVID-19 period (41.3 v. 39.6), whereas decreases were observed for endometrial cancer (15.9 v. 16.4), colorectal cancer (21.8 v. 24.3), prostate cancer (13.6 v. 18.5) and lung cancer (11.5 v. 15.9). For all cancer sites, there were no statistically significant differences in demographic characteristics, pathologic features or cancer stage between the 2 groups ($p > 0.05$). In multivariable regression analysis, for all cancer sites, cases staged during the pandemic were not associated with higher stage (breast: odds ratio [OR] 1.071, 95% confidence interval [CI] 0.826–1.388; colorectal: OR 1.201, 95% CI 0.869–1.661; endometrium: OR 0.792, 95% CI 0.495–1.252; prostate: OR 1.171, 95% CI 0.765–1.794; and lung: OR 0.826, 95% CI 0.535–1.262).

Interpretation: Cancer cases staged during the first year of the COVID-19 pandemic were not associated with higher stage; this likely reflects the prioritization of cancer procedures during times of reduced capacity. The impact of the pandemic period on staging procedures varied between cancer sites, which may reflect differences in clinical presentation, detection and treatment.

Throughout the COVID-19 pandemic, health care systems across Canada have grappled with major fluctuations in the delivery of health care services. Notably, the first wave, in March–June 2020, strained hospital capacity and supplies; to conserve limited resources, management of patients with COVID-19 and urgent non-COVID-19 conditions was prioritized.[1] This shift in resource allocation, in addition to changes in patient behaviour, resulted in decreased hospital admissions, emergency department visits and medical services.[2] In Ontario, there were a series of province-wide states of emergency related to COVID-19, which created further potential gaps in care.[3]

In the continuum of cancer care, patients may require access to a variety of medical services, including ambulatory clinics, imaging and laboratory testing, oncologic treatments and supportive care.[4] Previous studies showed reductions in cancer screening, testing and treatment during the

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COVID-19 pandemic,[5–9] and modelling studies have projected more cancer-related deaths as a result of the gaps in care.[10,11] Despite these projections, it is unclear whether health care disruptions resulted in changes in cancer stage and characteristics in the first year of the pandemic. This study sought to compare the pathologic stage and features of cancers staged in the 2 years before and the first year of the COVID-19 pandemic.

Methods

Setting and design

We performed a 3-year (March 2018–March 2021) retrospective cohort study at London Health Sciences Centre and St. Joseph's Health Care London, a network of academic tertiary hospitals in London, Ontario, Canada. In Canada, all medically necessary health care services are covered under a publicly funded health care system; the delivery and administration of health care services, including those related to the pandemic, generally occurs at the provincial level. The London Health Sciences Centre and St. Joseph's Health Care London cancer program is the regional referral centre for southwestern Ontario, serving a catchment area of more than 1.5 million people. We reported the study in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[12]

In Ontario, the pathologic staging of primary cancers is reported via an electronic standardized synoptic format, based on the College of American Pathologists Cancer Protocols templates.[13,14] These protocols are generally organized by disease site, with each protocol containing an established set of mandatory reporting items. We first used our institutional cancer reporting data to identify the 5 most common cancers by site (excluding nonmelanoma skin cancer). Using our departmental laboratory information system, we identified all cancer staging procedures for these sites performed between Mar. 15, 2018, and Mar. 14, 2021. We based the comparison groups on the surgery date: procedures performed between Mar. 15, 2018, and Mar. 14, 2020, were included in the pre-COVID-19 group, and procedures performed between Mar. 15, 2020, and Mar. 14, 2021, were included in the COVID-19 group. We used the cutoff of Mar. 15, 2020, because it was the start of the first province-wide ramping down of elective operations and nonemergent activities.[15] During these periods, hospitals in the province implemented measures to maintain readiness for a potential surge in COVID-19 cases, including reserving at least 10% of acute bed capacity and maintaining at least 15 days' worth of personal protective equipment. Guidelines for triaging and prioritizing cancer care were also developed.[16] Generally, surgical management for patients with cancer was prioritized in cases with greater risk of imminent morbidity or death, lower risk of COVID-19-related critical illness and lack of effective alternative treatments.

Data collection

We used the pathologic cancer stage group, determined with the tumour, lymph node, metastasis system of the eighth edition of the *AJCC Cancer Staging Manual*,[17] as the outcome variable. In cases in which pathologic staging was performed over multiple procedures, most commonly in breast cancers with separate sentinel lymph node sampling, we collated this information to determine the final stage group. We documented whether the case was staged as a tumour recurrence or after neoadjuvant therapy, and whether there were multiple primary tumours. In the case of multiple primary tumours, we used the tumour with the most advanced stage for analysis.

For all cases, we collected demographic information, including patient age and sex, as well as information regarding the specimen and procedure. For all primary cancers, we also extracted macroscopic and microscopic features that are included in the synoptic report but are not directly used for staging, with the variables specific to each cancer site. Generally, these features are indicators of tumour aggressiveness and may be used to inform prognosis or guide treatment decisions, or both. For breast and colorectal cancers, which have population-wide screening programs, we reviewed the patients' electronic medical records to determine the clinical presentation and whether the cancer was initially detected via screening.

We used the pathology reports and electronic medical records to extract data for analysis, and all cases were deidentified by means of a unique study identifier. The pathology reports and demographic information for the included cases were retrieved from our laboratory information system. Within the synoptic reports, the data fields containing the pathologic stage and cancer features were automatically extracted for analysis. The collected data were reviewed with the original pathology report to confirm accurate extraction.

Statistical analysis

We computed descriptive and summary statistics for the cohort. To compare cancer cases staged before and during the COVID-19 pandemic, we included only primary surgically treated cancers. Neoadjuvant-treated and recurrent cases were excluded for multiple reasons: the stage would not be an accurate reflection of the original disease; complete microscopic evaluation is often limited by posttreatment changes, particularly in cases with minimal or no residual tumour; and the case would not be reflective of a primary staging procedure because patients with neoadjuvant treatment or recurrence would already be in the cancer treatment pathway. We also excluded prostate cancer cases identified in radical cystoprostatectomy specimens, as these procedures were all performed for primary bladder cancers.

We performed univariate analyses to compare patient demographic characteristics, cancer features and stage. We used the Mann–Whitney test to evaluate differences in ordinal and continuous variables. For ordinal variables, if

Table 1 (part 1 of 2): Summary characteristics of cancer cases in the 2 years before the COVID-19 pandemic and the first year of the pandemic*

Site	No. (%) of cases†	
	2 years before pandemic	First year of pandemic
Breast	964	503
No. of cases per 30 d, mean	39.6	41.3
Age, median (IQR), yr	63 (52–71)	64 (54–73)
Sex		
Female	957 (99.3)	499 (99.2)
Male	7 (0.7)	4 (0.8)
Specimen		
Mastectomy	300 (31.1)	163 (32.4)
Excision	662 (68.7)	338 (67.2)
Other	2 (0.2)	2 (0.4)
Neoadjuvant treatment	155 (16.1)	90 (17.9)
Recurrence	24 (2.5)	29 (5.8)
Multiple primary tumours	144 (14.9)	69 (13.7)
Colorectum	592	265
No. of cases per 30 d, mean	24.3	21.8
Age, median (IQR), yr	71 (61–78)	70 (60–78)
Sex		
Female	258 (43.6)	113 (42.6)
Male	334 (56.4)	152 (57.4)
Specimen		
Right colon	251 (42.4)	116 (43.8)
Left colon	78 (13.2)	33 (12.4)
Rectal	225 (38.0)	100 (37.7)
Subtotal/total colectomy or proctocolectomy	28 (4.7)	11 (4.2)
Other	10 (1.7)	5 (1.9)
Neoadjuvant treatment	132 (22.3)	69 (26.0)
Recurrence	6 (1.0)	3 (1.1)
Multiple primary tumours	19 (3.2)	7 (2.6)
Prostate	449	165
No. of cases per 30 d, mean	18.5	13.6
Age, median (IQR), yr	65 (59–68)	64 (59–68)
Specimen		
Radical prostatectomy	405 (90.2)	141 (85.4)
Radical cystoprostatectomy	44 (9.8)	24 (14.5)
Neoadjuvant treatment	35 (7.8)	29 (17.6)
Multifocal tumours	87 (19.4)	36 (21.8)

Table 1 (part 2 of 2): Summary characteristics of cancer cases in the 2 years before the COVID-19 pandemic and the first year of the pandemic*

Site	No. (%) of cases†	
	2 years before pandemic	First year of pandemic
Endometrium	398	193
No. of cases per 30 d, mean	16.4	15.9
Age, median (IQR), yr	65 (59–72)	66 (58–72)
Specimen		
Hysterectomy type		
Simple/total	393 (98.7)	190 (98.4)
Other	5 (1.3)	3 (1.6)
NA	1 (0.2)	0 (0.0)
Bilateral salpingo-oophorectomy	369 (92.7)	180 (93.3)
< Bilateral salpingo-oophorectomy	16 (4.0)	8 (4.1)
Omentectomy	96 (24.1)	46 (23.8)
Neoadjuvant treatment	7 (1.8)	3 (1.6)
Lung	386	140
No. of cases per 30 d, mean	15.9	11.5
Age, median (IQR), yr	69 (63–75)	71 (66–76)
Sex		
Male	137 (35.5)	63 (45.0)
Female	249 (64.5)	77 (5.0)
Specimen		
Lobectomy	231 (59.8)	80 (57.1)
Wedge resection	89 (23.1)	34 (24.3)
Segmentectomy	15 (3.9)	9 (6.4)
Other	51 (13.2)	17 (12.1)
Neoadjuvant treatment	12 (3.1)	9 (6.4)
Recurrence	1 (0.3)	2 (1.4)
Multiple primary tumours	23 (6.0)	12 (8.6)

Note: IQR = interquartile range, NA = not applicable.
*Two years before COVID-19 pandemic: Mar. 15, 2018, to Mar. 14, 2020; first year of pandemic: Mar. 15, 2020, to Mar. 14, 2021.
†Except where noted otherwise.

there were fewer than 10 observations in a category, we combined those cases with the next-lowest or next-highest group. For binary and categoric variables, we used the χ^2 test or Fisher exact test, with the latter being used if there were fewer than 10 observations in a category. We calculated effect sizes for the baseline characteristics and stage. For continuous and binary characteristics, we calculated standardized mean differences.[18] For categoric variables, we calculated a multivariate Mahalanobis distance as a generalized standardized difference metric.[18] For binary and ordinal variables, we calculated a measure of stochastic dominance,[19] representing the probability that a randomly selected member of the COVID-19 group would be in a higher category than a randomly selected member of the pre-COVID-19 group.

Table 2: Univariate analysis comparing patient demographic characteristics, pathologic features and stage between breast cancers staged in the 2 years before the COVID-19 pandemic and in the first year of the pandemic

Variable	No. (%) of cases*		Standardized difference	Stochastic dominance	OR (95% CI)
	2 years before pandemic *n* = 788	First year of pandemic *n* = 387			
No. of cases per 30 d, mean	32.4	31.8			NA
Age, yr, median (IQR)	64 (54–72)	65 (55–73)	–0.079	–	NA
Sex					
Female	782 (99.2)	383 (99.0)	0.029	0.501	0.80 (0.22–2.85)
Male	6 (0.8)	4 (1.0)			1.25 (0.35–4.46)
Screening-detected					
No	462 (59.2)	243 (63.0)	0.078	0.481	1.16 (0.91–1.49)
Yes	319 (40.8)	143 (37.0)			0.85 (0.66–1.09)
NA	7	1			
Histologic subtype					
Ductal	559 (71.1)	273 (70.9)	0.120	–	0.99 (0.76–1.29)
Lobular	136 (17.3)	60 (15.6)			0.88 (0.63–1.23)
Mucinous	31 (3.9)	12 (3.1)			0.79 (0.40–1.55)
Other	60 (7.6)	40 (10.4)			1.41 (0.93–2.15)
NA	2	2			
Grade					
1	189 (24.2)	97 (25.5)	0.092	0.480	1.07 (0.81–1.42)
2	369 (47.3)	191 (50.1)			1.12 (0.88–1.43)
3	222 (28.5)	93 (24.4)			0.81 (0.61–1.07)
NA	8	6			
Lymphovascular invasion	142 (18.0)	65 (16.8)	0.032	0.494	0.92 (0.67–1.27)
Hormone status			0.035		
Other	686 (87.4)	342 (88.4)		0.495	1.10 (0.76–1.60)
HER2-overexpressed	39 (5.0)	19 (4.9)			0.98 (0.56–1.72)
Triple-negative	60 (7.6)	26 (6.7)			0.87 (0.54–1.41)
NA	3	0			
Positive margin	72 (9.1)	39 (10.1)	0.032	0.505	1.12 (0.74–1.69)
Extensive intraductal component	78 (9.9)	40 (10.3)	0.015	0.502	1.05 (0.70–1.56)
Stage					
I	420 (53.5)	199 (51.7)	–	0.508	0.93 (0.73–1.19)
II	283 (36.0)	145 (37.7)			1.07 (0.83–1.38)
III	82 (10.4)	41 (10.6)			1.02 (0.69–1.52)
NA	3	2			

Note: CI = confidence interval, HER2 = human epidermal growth factor receptor-2, IQR = interquartile range, NA = not applicable, OR = odds ratio.
*Except where noted otherwise.

To evaluate whether there was a statistically significant shift in cancer stage during the first year of the pandemic, we performed a multivariable ordered logistic regression analysis using the proportional odds model, with cancer stage as the outcome variable. This approach estimated the effect of the COVID-19 period on the odds of cancers being at a higher or lower stage. For each regression analysis, the model included the period (before or during the pandemic), demographic variables and site-specific risk features. We excluded binary variables from the model if

Table 3: Univariate analysis comparing patient demographic characteristics, pathologic features and stage between colorectal cancers staged in the 2 years before the COVID-19 pandemic and in the first year of the pandemic

Variable	No. (%) of cases*		Standardized difference	Stochastic dominance	OR (95% CI)
	2 years before pandemic *n* = 455	First year of pandemic *n* = 193			
No. of cases per 30 d, mean	18.7	15.9			NA
Age, median (IQR), yr	72 (64–80)	73 (61–79)	0.040	–	NA
Sex					
Female	204 (44.8)	90 (46.6)	0.036	0.491	1.08 (0.77–1.51)
Male	251 (55.2)	103 (53.4)			0.93 (0.66–1.30)
Screening-detected					
No	376 (83.2)	167 (87.0)	0.107	0.481	1.35 (0.84– 2.18)
Yes	76 (16.8)	25 (13.0)			0.74 (0.45–1.20)
NA	3	1			
Histologic subtype					
Adenocarcinoma	357 (78.6)	152 (78.8)	0.111	–	1.01 (0.67–1.53)
Mucinous adenocarcinoma	42 (9.3)	13 (6.7)			0.70 (0.37–1.34)
Other	55 (12.1)	28 (14.5)			1.23 (0.75–2.01)
NA	1	0			
Tumour size, median (IQR), cm	4.5 (3.0–6.0)	4.3 (3.3–6.0)	–0.025	–	NA
Lymphovascular invasion	247 (54.3)	110 (57.0)	0.055	0.514	1.12 (0.79–1.57)
Perineural invasion	113 (24.8)	50 (25.9)	0.025	0.506	1.06 (0.72–1.56)
Positive margin	57 (12.5)	19 (9.8)	0.085	0.487	0.76 (0.44–1.32)
Tumour perforation	16 (3.5)	8 (4.1)	0.033	0.504	1.18 (0.50–2.80)
Stage					
I	102 (22.5)	35 (18.1)	–	0.532	NA
II	164 (36.2)	66 (34.2)			
III	150 (33.1)	79 (40.9)			
IV	37 (8.2)	13 (6.7)			
NA	2	0			

Note: CI = confidence interval, IQR = interquartile range, NA = not applicable, OR = odds ratio.
*Except where noted otherwise.

there were fewer than 10 observations in 1 of the groups. Observations with incomplete data were omitted from the regression models. We calculated odds ratios (ORs) and 95% confidence intervals (CIs) for all variables. We used the Brant test to test the proportional odds assumption,[20] and generalized variance inflation factors to check for multicollinearity. A 2-tailed p value < 0.05 was used to define statistical significance. We performed all statistical analyses using R version 4.1.1 (R Foundation for Statistical Computing).

Ethics approval

Ethics approval was obtained from the Research Ethics Board at Western University and Lawson Health Research Institute (REB #119137).

Results

The 5 most common cancers by site were breast, colon/rectum, prostate, endometrium and lung. The cohort comprised 4055 cancer cases across the 5 sites (Table 1). The baseline patient demographic characteristics and procedures were similar between the 2 groups.

There was an increase in the average number of breast cancer cases per 30 days in the COVID-19 period compared to the yearly average in the pre-COVID-19 period (41.3 v. 39.6 [increase of 4.3%]), whereas decreases were observed for endometrial cancer (15.9 v. 16.4 [decrease of 3.0%]), colorectal cancer (21.8 v. 24.3 [decrease of 10.3%]), prostate cancer (13.6 v. 18.5 [decrease of 26.5%]) and lung cancer (11.5 v. 15.9 [decrease of 27.7%]). There was a greater rate

Table 4: Univariate analysis comparing patient demographic characteristics, pathologic features and stage between endometrial cancers staged in the 2 years before the COVID-19 pandemic and in the first year of the pandemic

Variable	No. (%) of cases*		Standardized difference	Stochastic dominance	OR (95% CI)
	2 years before pandemic *n* = 391	First year of pandemic *n* = 190			
No. of cases per 30 d, mean	16.1	15.6			NA
Age, median (IQR), yr	65 (59–72)	66 (58–72)	0.012	–	NA
Histologic subtype					
Endometrioid carcinoma, NOS	244 (62.7)	112 (58.9)	0.149	–	0.86 (0.61–1.23)
Endometrioid carcinoma, other variant	56 (14.4)	31 (16.3)			1.17 (0.72–1.88)
High-grade	88 (22.6)	47 (24.7)			1.13 (0.75–1.70)
Other	3	0			
Histologic grade					
Low	272 (69.6)	125 (65.8)	0.081	0.519	0.84 (0.58–1.22)
High	119 (30.4)	65 (34.2)			1.19 (0.82–1.72)
Lymphovascular invasion	115 (29.4)	64 (33.7)	0.092	0.521	1.22 (0.84–1.77)
Positive margin	6 (1.5)	3 (1.6)	0.004	0.500	1.07 (0.26–4.32)
Stage					
I	289 (73.9)	145 (76.3)	–	0.491	NA
II	38 (9.7)	13 (6.8)			
III + IV†	64 (16.4)	32 (16.8)			

Note: CI = confidence interval, IQR = interquartile range, NA = not applicable, NOS = not otherwise specified, OR = odds ratio.
*Except where noted otherwise.
†Grouped because there were fewer than 10 stage IV cases.

of neoadjuvant-treated cases for lung cancer (6.4% v. 3.1%), prostate cancer (17.6% v. 7.8%), colorectal cancer (26.0% v. 22.3%) and breast cancer (17.9% v. 16.1%) in the COVID-19 period than in the pre-COVID-19 period.

In the univariate analysis, there were no statistically significant differences in cancer stage distribution, pathologic features or demographic characteristics between the 2 groups (Tables 2, 3, 4, 5 and 6). The results of the multivariable ordinal logistic regression for all cancer sites are provided in Table 7. Across all cancer sites, after patient- and disease-specific factors were controlled for, having been staged in the COVID-19 period was not statistically associated with higher cancer stage at diagnosis.

Interpretation

In this study of the impact of the COVID-19 pandemic on cancer staging in a Canadian health care context, we did not find statistically significant differences in pathologic stage or features between cancers staged in the first year of the pandemic and those staged in the 2 years before the pandemic. There was no evidence that surgically treated cancers were more advanced or aggressive in the first year of the pandemic compared to the prepandemic period.

Our analysis included the 5 most commonly staged cancers, all with a variety of risk factors, pathophysiologic features and clinical characteristics. Although we did not observe any statistically significant differences between the 2 periods, our findings provide insight into cancer care patterns during the pandemic. Despite disturbances in delivery of health care services, the number of cases of breast and endometrial cancers was similar to that in the prepandemic period, whereas a modest decrease of 10.3% was observed for colorectal cancer. These findings reflect the prioritization of oncologic surgical procedures during the lockdown period[21] and are consistent with previous studies showing that oncologic surgery volumes were not as severely affected as other surgery types.[7,22] Furthermore, the COVID-19 period also included extended times with resumed clinical activity, which allowed greater capacity to treat patients waiting for surgery. Although there were service reductions, particularly at the beginning of the pandemic, the number of surgically treated cases in the first year was maintained for breast and endometrial cancers.

In contrast, there were markedly fewer staging procedures for prostate and lung cancers, likely because there are no population-wide screening programs for these cancers and it is not uncommon for these patients to be

Table 5: Univariate analysis comparing patient demographic characteristics, pathologic features and stage between endometrial cancers staged in the 2 years before the COVID-19 pandemic and in the first year of the pandemic

Variable	No. (%) of cases*		Standardized difference	Stochastic dominance	OR (95% CI)
	2 years before pandemic *n* = 372	First year of pandemic *n* = 113			
No. of cases per 30 d, mean	15.3	9.3			NA
Age, median (IQR), yr	64 (59–68)	63 (58–67)	0.081	–	NA
Histologic subtype				–	
Acinar adenocarcinoma	349 (93.8)	109 (96.5)	0.123		1.80 (0.61–5.31)
Acinar adenocarcinoma with mixed features	23 (6.2)	4 (3.5)			0.56 (0.19–1.65)
Gleason Grade Group†					
1 + 2	274 (73.7)	79 (69.9)	0.083	0.519	0.83 (0.52–1.32)
3–5	98 (26.3)	34 (30.1)			1.21 (0.76–1.92)
Intraductal carcinoma	102 (27.4)	37 (32.7)	0.116	0.473	1.29 (0.82–2.03)
Lymphovascular invasion	34 (9.1)	14 (12.4)	0.105	0.516	1.41 (0.73–2.74)
Perineural invasion	329 (88.4)	105 (92.9)	0.155	0.478	1.72 (0.78–3.77)
Margin status					
Negative	249 (66.9)	73 (64.6)	–	0.503	0.90 (0.58–1.40)
Limited positive	59 (15.9)	25 (22.1)			1.50 (0.89–2.53)
Nonlimited positive	64 (17.2)	15 (13.3)			0.74 (0.40–1.35)
Stage					
I + II‡	161 (43.3)	44 (38.9)	–	0.525	NA
III	184 (49.5)	59 (52.2)			
IV	27 (7.3)	10 (8.8)			

Note: CI = confidence interval, IQR = interquartile range, NA = not applicable, OR = odds ratio.
*Except where noted otherwise.
†Grouped because there were fewer than 10 cases for each of Gleason Grade Groups 1, 4 and 5.
‡Grouped because there were fewer than 10 stage I cases.

asymptomatic at presentation.[23–26] As a result, reductions in other types of clinical services may have limited opportunities to diagnose incident cases.[2] Another possibility is that primary surgical staging for some cancers may have been reduced in favour of first-line drug or radiation therapy. During the pandemic, cancer treatment pathways have been modified, with triaging based on a combination of patient (e.g., risk of COVID-19 as an inpatient), disease (e.g., cancer stage and aggressiveness, risk of death and morbidity, and options for effective nonsurgical treatments), resource and COVID-19-related risk factors,[16] with variable impact. In another Canadian study, Kasymjanova and colleagues[27] observed a significant decrease in lung cancer cases during the early pandemic period, along with a reduction in surgical procedures as the primary treatment modality. In our study, the greatest increase in neoadjuvant-treated cases during the COVID-19 period was observed for prostate cancer.

For breast and colon cancers, we found that screening-detected cases were statistically significant predictors of lower stage. This highlights the role of these screening programs in detecting early-stage cancers. It is also important to emphasize the crucial role of screening in primary cancer prevention, through the detection and removal of precancerous lesions. We previously described how our institutional surgical pathology volumes changed during the first 4 months of the pandemic, with biopsy volumes more severely affected than surgical resections, which likely represented decreases in diagnostic and screening procedures.[22] Given that premalignant lesions in the breast and colon can take multiple years before progressing to cancer,[28,29] the consequences of changes in screening use may not be observable for several years. Likewise, longer-term surveillance is required to fully understand the impact of health care–related changes on cancer patterns.

Cancer outcomes are not only influenced by stage, but are also affected by access to high-quality diagnostic tests and treatments.[30,31] Our study took place at a tertiary care centre in a publicly funded health care system. As in many

Table 6: Univariate analysis comparing patient demographic characteristics, pathologic features and stage between lung cancers staged in the 2 years before the COVID-19 pandemic and in the first year of the pandemic

Variable	No. (%) of cases*		Standardized difference	Stochastic dominance	OR (95% CI)
	2 years before pandemic *n* = 373	First year of pandemic *n* = 129			
No. of cases per 30 d, mean	15.3	10.6			NA
Age, median (IQR), yr	70 (63–75)	71 (64–76)	–0.050	–	NA
Sex					
Female	240 (64.3)	73 (56.6)	0.159	0.539	0.72 (0.48–1.09)
Male	133 (35.7)	56 (43.4)			1.38 (0.92–2.08)
Histologic type					
Adenocarcinoma	236 (63.3)	89 (69.0)	0.207	–	1.29 (0.84–1.98)
Squamous cell carcinoma	70 (18.8)	25 (19.4)			1.04 (0.63–1.73)
Carcinoid	36 (9.7)	6 (4.7)			0.46 (0.19–1.12)
Other	31 (8.3)	9 (7.0)			0.83 (0.38–1.80)
Lymphovascular invasion	57 (15.3)	28 (21.7)	0.166	0.532	1.53 (0.93–2.54)
Positive margin	18 (4.8)	5 (3.9)	0.047	0.495	0.80 (0.29–2.21)
Stage					
I	239 (65.1)	83 (64.3)	–	0.497	NA
II	72 (19.6)	31 (24.0)			
III + IV†	56 (15.3)	15 (11.6)			
NA	6	0			

Note: CI = confidence interval, IQR = interquartile range, NA = not applicable, OR = odds ratio.
*Except where noted otherwise.
†Grouped because there were fewer than 10 stage IV cases.

other hospitals during the first year of the pandemic, enormous strains were placed on hospital resources, along with multiple periods of reduced surgical activity. Despite these challenges, system-level measures to prioritize cancer treatment appear to have protected patients from disease progression related to delays in care. Variable reductions in staging procedures were observed across different cancer sites. Given the reductions in surgery rates worldwide, it is important to deduce whether this represents reductions in diagnoses or treatment, or both. As health care systems allocate resources under continually changing conditions, addressing gaps in cancer care will be important to ensure that patients receive fair and equitable access to health care services, and to optimize patient outcomes.

Limitations

We used pathologic staging data, which are based on the gross and microscopic examination of tissues. Pathologic stage may differ from clinical stage if there are findings on imaging that are not assessed at the tissue level. Furthermore, some metastatic (stage IV) cancers may not have been captured in our data, as these patients often do not undergo surgery. However, given the similar rates of cases, particularly for breast, colorectal and endometrial cancers, it is unlikely that a marked increase in metastatic cases would have arisen in the first year of the pandemic.

There is likely regional variation in how cancer staging has changed during the COVID-19 pandemic, depending on local infection rates, availability of resources, and government and hospital policy. Temporal changes will also have inevitably occurred, as health care systems grapple with additional waves and fluctuations in clinical activity. Nonetheless, our study provides a broad overview of cancer staging patterns during the first year of the COVID-19 pandemic, and the findings serve as valuable baseline data going forward.

Although we did not detect changes in cancer staging at the population level, no doubt individual patients have experienced clinically meaningful delays in accessing cancer services. For patients with cancer during the pandemic, the health care changes and uncertainty have resulted in greater emotional and mental stress.[32–34] We focused on cancer stage as the primary outcome, but resource planning must also include supportive treatments to address patient well-being, so that patients receive high-quality, comprehensive cancer care.

Table 7: Multivariate ordinal regression for pathologic cancer stage

Site*	OR (95% CI)
Breast, *n* = 1150	
COVID-19 period	1.071 (0.826–1.388)
Age	1.009 (1.000–1.019)
Screen-detected	0.246 (0.186–0.324)
Grade	2.308 (1.756–3.044)
Lymphovascular invasion	5.522 (3.968–7.730)
High-risk hormone status	1.102 (0.791–1.531)
Extensive intraductal component	0.890 (0.573–1.365)
Positive margin	1.351 (0.901–2.017)
Colorectal, *n* = 638	
COVID-19 period	1.201 (0.869–1.661)
Age	0.996 (0.984–1.008)
Male sex	1.119 (0.828–1.512)
Screen-detected	0.398 (0.254–0.618)
Tumour size	1.178 (1.105–1.259)
Lymphovascular invasion	3.799 (2.731–5.314)
Perineural invasion	2.383 (1.628–3.506)
Positive margin	3.764 (2.261–6.334)
Endometrium, *n* = 572	
COVID-19 period	0.792 (0.495–1.252)
Age	1.002 (0.980–1.025)
High-grade	4.922 (3.173–7.700)
Lymphovascular invasion	5.729 (3.714–8.915)
Prostate, *n* = 485	
COVID-19 period	1.171 (0.765–1.794)
Age	1.027 (0.997–1.058)
High Gleason Grade Group (3–5)	2.736 (1.687–4.510)
Intraductal carcinoma	2.744 (1.795–4.243)
Lymphovascular invasion	17.849 (8.423–39.749)
Positive margin	1.778 (1.239–2.576)
Lung, *n* = 496	
COVID-19 period	0.826 (0.535–1.262)
Age	1.003 (0.984–1.023)
Male sex	1.888 (1.292–2.761)
Lymphovascular invasion	4.310 (2.730–6.829)

Note: CI = confidence interval, OR = odds ratio.
*Number of cases omitted owing to incomplete data: breast 25, colorectal 10, endometrium 9, lung 6.

Conclusion

We did not find a statistically significant shift in cancer stage in the first year of the COVID-19 pandemic compared to the 2 years before the pandemic. There were variable reductions in the number of cases across cancer sites, which likely reflect differences in clinical presentation, disease detection and treatment. Long-term surveillance is required to fully understand the impact of COVID-19-related health care changes on cancer outcomes at the population level.

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